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Soil Resource Report

Little Deer Project

Goosenest Ranger District, Klamath National Forest
Siskiyou County, California

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The unit measures for soil organic matter and soil structure indictors are acres not meeting desired conditions. Soil organic matter desired conditions are not met when major portions of the area have had the upper soil layer displaced or removed to a depth of 8 inches and an area large enough to affect productivity for the desired plant species (100 square feet). Soil structure desired conditions are not met when major portions of the area have reduced infiltration and permeability capacity indicated by soil structure and macro-porosity changes. Infiltration is the process by which water on the ground surface enters the soil. Soil macro-porosity is the amount of the soil that is composed of larger pores which are important for soil water movement and gas exchange.

The proposed activities for the project were categorized into similar activity types. For example, all treatments using ground-based equipment were lumped into "Ground Based Tractor Logging with Associated Landings." The projected acres not meeting desired conditions for each indicator and activity type were determined from monitoring data collected from previous projects on the Forest using the National Forest Soil Disturbance Monitoring Protocol. Percent of treatment acres in main skid trails and landings were also determined from monitoring previous vegetation management projects on the Forest. Miles of temporary roads on existing roadbeds is described in chapter 2.

Spatial and Temporal Context

For all four soil indicators, the analysis area is bounded by the project activity treatment stands, where project activities take place. The analysis is further bounded in time by the foreseeable future period during which effects of this project could persist as detectable, significant effects. Soil organic matter can take years to decades to rebuild after it is lost through displacement or erosion. Once compacted, structure can remain affected for decades as biological and physical processes work to break up compaction. Some skid trails, landings, and temporary roads are often still evident on the landscape for decades after treatment. The temporal boundary for soil organic matter, soil structure, miles of temporary roads on existing roadbeds, and percent of treatment acres in skid trails and landings is 30 years.

Affected Environment

Soils in the Little Deer project area comprised of loams, gravelly loams, sandy loams, and sands developed from volcanic ash and weathered basalt or andesite. The majority of the soils in the project area are deep sandy loams derived from volcanic ash. These soils have a low compaction hazard rating and rated as having low productivity due to high amounts of volcanic cinders. Soils to the north of Little Deer Mountain are gravelly loams formed from weathered andesite and

basalt and have moderate compacting and productivity rating. Soils on the east side of the project area are loams formed from weathered andesite and basalt and have high compaction hazard rating and low to moderate productivity rating. Little Deer Mountain and lava flows to the southwest of Little Deer Mountain are rated as non-productive lands composed of cinders and un-weathered bedrock.

Erosion hazard rating is a relative measure of the soils' sensitivity to erosion processes. Soil disturbance has the potential to increase the erosion hazard because soil cover is generally reduced. Erosion hazard rating was calculated for each of the treatment units to estimate the potential erosion hazard for a given soil type. The maximum erosion hazard rating was calculated for soil that is completely bare to determine the risk of soil loss in areas without protection from soil cover. The maximum erosion hazard rating in the majority of the project area is moderate due to gentle to moderate slopes and sandy soil textures. Cinder lands and lava flows are rated has having low erosion hazard rating because these areas are well armored with surface rock.

The erosion hazard rating for the current conditions of treatment areas was calculated using data collected on existing levels of soil cover and from soil burn severity mapping. Areas with high and moderate soil burn severity have reduced levels of soil cover and therefore have current erosion hazard ratings equal to maximum erosion hazard rating.

Site data was stratified to collect information on the existing conditions for a variety of soil types in moderate and high soil burn severity areas. Soil texture, soil cover, rock content, soil burn severity, disturbance from old skid trails, landings, roads, as well as disturbance from fire suppression activities was evaluated along five transects in the project area. Existing soil cover averaged 32 percent in units with high soil burn severity and 61 percent in units with moderate soil burn severity. The types of disturbance that were found include topsoil displacement, compaction, and rutting on dozer lines from fire suppression activities, old road beds, skid trails, and landings. No signs of soil erosion were present on any of the surveyed units.

Desired conditions for soil organic matter and soil structure are currently met on an average of 96 percent of the proposed treatment area. Ground disturbance from previous timber sales and fire suppression activities account for a minor portion of treatment units.

Environmental Consequences

Alternative 1

Direct Effects and Indirect Effects

Direct and indirect effects of this alternative will be a slow natural recovery of soil cover as vegetation re-establishes on the moderate and high soil burn severity areas. Soil organic matter will remain intact unless severe storm events result in the loss of large amounts of topsoil. Soil structure conditions will remain the same in the short term, with very slow long-term natural recovery of old skid trails and landings.

Cumulative Effects

Cumulative effects are influenced by the direct and indirect effects of this alternative added to the effects of applicable past, ongoing, and reasonably foreseeable future actions. Past actions including timber harvest and fire suppression are evident on the landscape in the project area and

are reflected in the discussion of the affected environment. The Horsethief grazing allotment project is an ongoing and reasonably foreseeable future action that is being planned in the project area. Current grazing use is light in the areas proposed for treatment in the Little Deer project. The Horsethief grazing allotment project is not expected to increase the level of use in the Little Deer project area so cumulative impacts to soil indicators are not expected to be substantial.

Alternative 2

Numerous scientific studies and review articles have been written describing the impacts of salvage logging (dead tree removal) on soil functions. These studies and review articles conclude that salvage logging occurs on soil that is disturbed and more vulnerable to additional disturbance than green timber sales (Lindenmayer & Noss, 2006) and that salvage logging operations damage soils by compaction, displacement, and increased topsoil erosion (Beschta 1995; Karr et al., 2004). A study on the Biscuit Fire in Southern Oregon found that salvage logging significantly increases both fine and coarse downed wood fuel loads, elevating the short term risk of damage to soil from re-burn (Donato, et al., 2006). Additionally, research has shown that salvage logging removes large standing trees that are an important component to soil biological processes and nutrient cycling (Karr, et al., 2004; Marañón-Jiménex et al. 2013). Researchers have concluded that salvage logging negatively impacts recovery processes with the intensity of such impacts depending upon the nature of logging activity (Noss et al. 2006). The Soil resource report acknowledges the negative impacts of salvage logging on soil functions and quantifies these impacts using monitoring and relevant science.

Direct Effects and Indirect Effects

Ground-based tractor logging, roadside hazard tree removal, site preparation, and temporary road reconstruction will impact the number of acres not meeting desired conditions for soil organic matter and soil structure. For alternative 2, the acres that do not meet desired conditions for soil organic matter and soil structure are 367 and 232. These acres include impacts from old skid trails, landings, and roads as well as estimated additional acres from activities proposed in alternative 2. Reusing skid trails, landings, and existing roadbeds will limit most of the negative impacts from project activities to areas of existing soil disturbance. Ground based tractor logging will result in reduced levels of soil cover on skid trails and landings but design features will reduce the potential for soil erosion. Increased compaction and soil displacement will lead to a loss of soil function on main skid trails landings and temporary roads. Project design features (table 2-1) including slope limitations, waterbar requirements, disturbance limitations, minimizing impacts to coarse woody debris, and subsoiling will minimize impacts to soil erosion and productivity.

Alternative 2 proposes to use 9.3 miles of temporary roads on existing roadbeds. Reusing existing roadbeds will limit additional disturbance from project activities as these currently do not meet desired conditions for soil organic matter and soil structure. Project design features to grade, out-slope, block, and provide adequate soil cover will limit impacts to temporary roads on existing roadbeds.

The percent of treatment acres in main skid trails and landings is expected to be about 8 percent. The majority of these will be on reused existing skid trails and landings. Implementation of project design features will reduce the potential for negative effects from these activities.

Alternative 2 will maintain adequate soil cover, protect soil organic matter, maintain soil structure at levels sufficient to protect soil productivity, and prevent soil erosion.

Monitoring from previous projects has shown that implementation of project design features for ground-based logging and temporary road use are effective at minimizing impacts to soil functions. Alternative 2 will maintain adequate soil cover, protect soil organic matter, and maintain soil structure at levels sufficient to protect soil productivity and prevent soil erosion. For more detail on how the proposed activities may impact soil function, please see the Soil resource report.

Cumulative Effects

Past actions including timber harvest and fire suppression are evident on the landscape in the project area and are reflected in the discussion of the affected environment. The effects of ongoing cattle grazing and the Horsethief grazing allotment project are the same as discussed for alternative 1. Adding the effects of alterative 2 to the effects of past, present, and reasonably foreseeable future actions is not expected to have substantial negative effects on soil desired conditions and, therefore, no substantial negative cumulative effects will occur.

Alternative 3

Direct Effects and Indirect Effects

The proposed activities with a potential to impact soil organic matter and soil structure are the same as alternative 2 but the number of acres treated with ground-based tractor logging are decreased and planting/seeding proposed only in the dead tree treatment areas. For alternative 3, the acres that will not meet desired conditions for soil organic matter and soil structure are 315 and 207. These acres include impacts from old skid trails, landings, and roads as well as estimated additional acres from activities proposed in alternative 3. The miles of temporary roads on existing roadbeds are slightly reduced at 9 miles. The percent of treatment acres in main skid trails and landings is expected to be slightly reduced at 7 percent.

Cumulative Effects

Adding the effects of alterative 3 to the effects of past, present, and reasonably foreseeable future actions is not expected to have substantial negative effects on soil desired conditions and, therefore, no substantial negative cumulative effects will occur.

Comparison of Effects

Table S- 1: Comparison of effects of alternatives on soil indicators

Indicator	Alternative 1	Alternative 2	Alternative 3
Acres not meeting desired conditions for soil organic matter	87	367	315
Acres not meeting desired conditions for soil structure	87	232	207
Miles of temporary roads on existing roadbeds	0	9.3	9
Percent of treatment area in main skid trails and landings	0	8%	7%

Compliance with law, regulation, policy, and the Forest Plan

Forest Plan standards for soils will be met for all alternatives as displayed in the Forest Plan consistency checklist, available on the project website. The number of acres that do not meet desired conditions for soil organic matter and soil structure is minor in relation to the total treatment area, and is reduced to the extent possible with project design features.

Soil Report

Introduction

Analysis of the effects of individual management activities on the soil resource (soil productivity and soil ecosystem functionality) is guided by the Forest Plan Standards and Guidelines and FSM 2500, Chapter 2550, Supplement 2500-2012-1. Four indicators were chosen that address relevant issues in the Little Deer Project and measure compliance with Forest Plan Standard and Guidelines. The indicators include: soil organic matter, soil structure, miles of temporary roads on existing roadbeds, and percent of treatment acres in main skid trails and landings.

For a detailed description of the alternatives considered for analysis and project design features, see Chapter 2 of the Little Deer Project EA.

Methodology

A unit selection strategy was used to determine which units should have site-specific data collected. Selection was based on soil sensitivity and type of management activities planned. Soils with high compaction or erosion hazard ratings and areas with evidence of previous disturbance received a high priority for field review. Units proposed for ground-based commercial harvest have the highest probability of impacting the soil resource so those units were also a high priority for field review. Field investigation was done by making two to three traverses across each unit. Site and soil data was collected from plots along these traverses. Soil cover, soil burn severity, erosion, and evidence of previous disturbance were noted. The level of soil disturbance was estimated for each soil disturbance type. Soil data noted in the field included shallow soil areas, rock outcrop, areas of surface rock, rock lithology and general soil depth. Existing soil survey information (Foster and Lang, 1994) was used unless field investigation revealed significant differences between mapped soils and the actual site-specific soils. See appendices A, B, and C for a soil unit map and related information.

Analysis Indicators

Four indicators were chosen to address relevant issues in the Little Deer Project and measure compliance with Forest Plan Standard and Guidelines. The indicators include: soil organic matter, soil structure, miles of temporary roads on existing roadbeds, and percent of treatment acres in main skid trails and landings.

The unit measures for soil organic matter and soil structure indictors are acres not meeting desired conditions. Soil organic matter desired conditions are not met when major portions of the area have had the upper soil layer displaced or removed to a depth of 8 inches and an area large enough to affect productivity for the desired plant species (100 square feet). Soil structure desired conditions are not met when major portions of the area have reduced infiltration and permeability capacity indicated by soil structure and macro-porosity changes. Infiltration is the process by which water on the ground surface enters the soil. Soil macro-porosity is the amount of the soil that is composed of larger pores which are important for soil water movement and gas exchange.

The proposed activities for the Project were categorized into similar activity types. For example, all treatments using ground-based equipment were lumped into “Ground Based Tractor Logging with Associated Landings”. The projected acres not meeting desired conditions for each indicator and activity type were determined from monitoring data collected from previous

projects on the Forest using the National Forest Soil Disturbance Monitoring Protocol. Percent of treatment acres in main skid trails and landings were also determined from monitoring previous vegetation management projects on the Forest. Miles of temporary roads on existing roadbeds is described in Chapter 2 of the Little Deer EA.

Table 1: Indicator Condition Assessment

		Indicator Conditions		
		Good	Fair	Poor
Soil Function	Indicators	Meets Desired Condition	Partially Meets Desired Condition	Does Not Meet Desired Condition
Support for Plant Growth	Soil Organic Matter (SOM)	The thickness and color of the upper soil layer is within the normal range of characteristics for the site and is distributed normally across the area. Localized areas of displacement may have occurred but it will not affect the productivity for the desired plant species.	For minor portions of the area, the upper soil layer has been displaced or removed to a depth and area large enough to affect productivity for the desired plant species. Generally an area will be considered displaced if more than one-half of the upper soil layer or 4 inches (whichever is less) is removed from a contiguous area larger than 100 feet squared.	Major portions of the area have had the upper soil layer (8 inches) displaced or removed to a depth and area large enough to affect productivity for the desired plant species.
Soil Hydrologic Function	Soil Structure	Visually soil structure and macro-porosity (defined here as pores 1mm or larger) are relatively unchanged from natural condition for nearly all the area. Signs of erosion or overland flow are absent or very limited in degree and extent. Infiltration and permeability capacity of the soil is sufficient for the local climate.	For minor portions of the area: soil structure and macro-porosity are changed; or platy structure and/or increased density evident; or overland flow and signs of erosion are visible. Infiltration and permeability capacity is insufficient in localized portions of the area.	Major portions of the area have reduced infiltration and permeability capacity indicated by soil structure and macro-porosity changes; or platy structure and/or increased density; or signs of overland flow and erosion.

Risk Assessments

Compaction Risk Rating

This risk rating scheme is intended to help determine the general susceptibility to loss of soil productivity from heavy equipment operation. It considers the risk that compaction will occur, and if compaction would result in productivity loss. It is based upon the soil texture and rock content. It presumes the soil is at field capacity or at a moisture level at which it is most susceptible to soil density increase under heavy equipment operation (USDA, 2006). Table 2 below displays compaction risk rating.

Table 2: Compaction Risk Rating

Coarse Fragment Content by Volume	Soil Texture	Hazard Rating
Fragmental (> 70%)	Any Texture	Low
Skeletal (35 - 70%)	Sandy	Low
Skeletal (35 - 70%)	Loamy	Moderate
Skeletal (35 - 70%)	Clayey	High
< 35%	Sandy	Low
< 35%	Loamy	Moderate
< 35%	Silty	High
< 35%	Clayey	High

Erosion Risk Rating

The Region 5 Soil Erosion Hazard Rating (EHR) System was used to rate the risk of soil erosion for all soils in the project area. This system uses various physical soil properties along with climate and site-specific conditions to rate soils for hazard of sheet and rill erosion. This system is used to determine the amount of surface cover necessary post-activity to keep erosion hazard risk low or moderate (USDA, 1990). In addition to the EHR system, the Klamath LRMP describe levels of total soil cover that should be maintained at the stand level to reduce the potential of soil erosion (Table 3).

Table 3: Soil Cover Guidelines for Vegetation and Fuels Management Projects

Soil Texture Class	Slope (%)	Minimum Total Soil Cover* (%)
Guidelines for Projects Using Tractors:		
Sandy loam or coarser	0-25	70
	26-35	80
Loam or finer	0-35	70
Guidelines for Prescribed Burning Projects:		
Sandy loam or coarser	0-25	60
	26-45	70
	46	80
Loam or finer	0-35	50
	36-60	60
	61	70
*Soil cover consists of low growing live vegetation (12 inches high), rock fragments (greater than ½ inch in diameter), slash (any size), and fine organic matter (charred or not) that is in contact with the soil surface. Fine organic matter refers to the duff, litter, and twigs less than three inches in diameter.		

Spatial and Temporal Bounding of Analysis Area

For all four soil indicators, the analysis area is bounded by the project activity treatment stands, where project activities take place. The analysis is further bounded in time by the foreseeable future period during which effects of this project could persist as detectable, significant effects.

Soil organic matter can take years to decades to rebuild after it is lost through displacement or erosion. Once compacted, structure can remain affected for decades as biological and physical processes work to break up compaction. Some skid trails, landings, and temporary roads are often still evident on the landscape for decades after treatment. The temporal boundary for soil organic matter, soil structure, miles of temporary roads on existing roadbeds, and percent of treatment acres in skid trails and landings is 30 years.

Affected Environment

Soils in the Little Deer project area comprised of loams, gravelly loams, sandy loams, and sands developed from volcanic ash and weathered basalt or andesite. The majority of the soils in the project area are Oosen-Avis Families complex which are deep sandy loams derived from volcanic ash. These soils have a low compaction hazard rating are rated as having low productivity due to high amounts of volcanic cinders. Soils to the north of Little Deer Mountain are classified as Inville Family which are gravelly loams formed from weathered andesite and basalt and have moderate compacting and productivity rating. Soils on the east side of the project area are Etchen and Trojan soil families which are loams formed from andesite and basalt and have high compaction hazard rating and low to moderate productivity rating. Little Deer Mountain and lava flows to the southwest of Little Deer Mountain are rated as non-productive lands composed of cinders and unweather bedrock.

Erosion hazard rating (EHR) is a relative measure of the soils' sensitivity to erosion processes. Soil disturbance has the potential to increase the erosion hazard because soil cover is generally reduced. Erosion hazard rating was calculated for each of the treatment units to estimate the potential erosion hazard for a given soil type. The maximum EHR was calculated for soil that is completely bare to determine the risk of soil loss in areas without protection from soil cover. The maximum EHR in the majority of the project area is moderate due to gentle to moderate slopes and sandy soil textures. Cinder lands and lava flows are rating has having low erosion hazard rating because these areas are well armored with surface rock.

The EHR for the current conditions of treatment areas was calculated using data collected on existing levels of soil cover and from soil burn severity mapping. Areas with high and moderate soil burn severity have reduced levels of soil cover and therefore have current erosion hazard ratings equal to maximum EHR.

According to the Little Deer Burned Area Emergency Response (BAER) report 35 percent of the soils in the fire area burned at low or very low severity showing very little evidence of significant soil heating with essentially no changes in soil color, structure, organic matter or fine root combustion (USDA 2014). Moderate soil burn severity was report at 55 percent of the burn area were soil heating was generally not hot enough to alter soil structure or fine roots in the topsoil. High soil burn severity was report at 13 percent of the fire area. These areas have deeper soil heating effects and compromised soil structure and organic matter, leading to higher erosion hazard and slower natural recovery. The units proposed from treatment in the Little Deer project are concentrated in the moderate and high soil severity burn areas.

Site data was stratified to collect information on the existing conditions for a variety of soil types in moderate and high soil burn severity areas. Soil texture, soil cover, rock content, soil burn severity, disturbance from old skid trails, landings, roads, as well as disturbance from fire suppression activities was evaluated along five transects in the project area. Existing soil cover averaged 32% in units with high soil burn severity and 61% in units with moderate soil burn

severity. The types of disturbance that were found include topsoil displacement, compaction, and rutting on a dozer line from fire suppression activities, old road beds, skid trails, and landings. No signs of soil erosion were present on any of the surveyed units.

Desired conditions for soil organic matter and soil structure are currently met on an average of 96% of the proposed treatment area. Ground disturbance from previous timber sales and fire suppression activities account for a minor portion of treatment units.

Environmental Consequences

Alternative 1

Direct and Indirect Effects

Direct effects of the No Action alternative will have no effect on the soils, as soil disturbing project activities will not take place. Indirect effects of this alternative will be a slow natural recovery of soil cover as vegetation re-establishes on the moderate and high soil burn severity areas. Soil organic matter will remain intact unless severe storm events result in the loss of large amounts of topsoil. Soil structure conditions will remain the same in the short term, with very slow long-term natural recovery of old skid trails and landings. For the No Action alternative, 87 acres do not meet desired conditions for soil organic matter and soil structure. These acres are found on old skid trails, landings, and roads where soil displacement and compaction are still at levels that impact soil functions. Percent of treatment acres in new skid trails; landings and miles of temporary roads on existing roadbeds will be zero.

Cumulative Effects

Cumulative effects are influenced by the direct and indirect effects of this alternative added to the effects of applicable past, ongoing, and reasonably foreseeable future actions. Past actions including timber harvest and fire suppression are evident on the landscape in the project area and are reflected in the discussion of the affected environment. The Bray and Horsethief Grazing Allotments Project is a reasonably foreseeable future action that is being planned in the project area. Current grazing use is light in the areas proposed for treatment in the Little Deer Project. The Bray and Horsethief Grazing Allotment Project is not expected to change the level of use in the Little Deer Project Area so cumulative impacts to soil indicators are not expected to be significant.

Alternative 2

Numerous scientific studies and review articles have been written describing the impacts of salvage logging on soil functions. These studies and review articles conclude that salvage logging occurs on soil that is disturbed and more vulnerable to additional disturbance than green timber sales (Lindenmayer & Noss, 2006) and that salvage logging operations damage soils by compaction, displacement, and increased topsoil erosion (Beschta 1995; Karr et al., 2004). A study on the Biscuit Fire in Southern Oregon found that salvage logging significantly increases both fine and coarse downed wood fuel loads, elevating the short term risk of damage to soil from re-burn (Donato, et al., 2006). Additionally, research has shown that salvage logging removes large standing trees that are an important component to soil biological processes and nutrient cycling (Karr, et al., 2004; Marañón-Jiménex et al. 2013). Researchers have concluded that salvage logging negatively impacts recovery processes with the intensity of such impacts depending upon the nature of logging activity (Noss et al. 2006). The *Soil Resource Report*

acknowledges the negative impacts of salvage logging on soil functions and quantifies these impacts using monitoring and relevant science.

Direct and Indirect Effects

Ground-based tractor logging, roadside hazard tree removal, site preparation, and temporary road reconstruction will impact the number of acres not meeting desired conditions for soil organic matter and soil structure. For Alternative 2, the acres that do not meet desired conditions for soil organic matter and soil structure are 367 and 232. These acres include impacts from old skid trails, landings, and roads as well as estimated additional acres from activities proposed in Alternative 2. Reusing skid trails, landings, and existing roadbeds will limit most of the negative impacts from project activities to areas of existing soil disturbance. A summary of estimated acres in Alternative 2 that do not meet desired conditions for soil organic matter, and soil structure is in Table 4.

Alternative 2 proposes to use 9.3 miles of temporary roads on existing roadbeds. Reusing existing roadbeds will limit additional disturbance from project activities as these currently do not meet desired conditions for soil organic matter and soil structure. Project design features to grade, out-slope, block, and provide adequate soil cover will limit impacts to temporary roads on existing roadbeds.

The percent of treatment acres in main skid trails and landings is expected to be about 8 percent. The majority of these will be on reused existing skid trails and landings. Implementation of project design features will reduce the potential for negative effects from these activities. Alternative 2 will maintain adequate soil cover, protect soil organic matter, maintain soil structure at levels sufficient to protect soil productivity, and prevent soil erosion.

Dead Tree Removal

Standing dead trees four inches in diameter at breast height or greater will be removed from the project area by ground-based tractor logging. Ground based tractor logging with associated landings will result in reduced levels of soil cover on skid trails and landings. However, salvage logging operations can generate slash, adding ground cover to reduce erosion. Studies in Northern California have shown 12 to 38 percent increases in soil cover, compared to unlogged units, from woody debris as a result of salvage logging activities (Chase, 2006 and Poff, 1989). In some cases, salvage logging can be used to break up hydrophobic soil layers near the surface, further reducing erosion (Poff, 1996). However, this benefit may be offset by other soil disturbance associated with salvage logging. Recent research has shown a 10-100 fold increase in sediment production from ground-based tractor salvage logging (Wagenbrenner et al. 2014, however other research on slopes and soil types more similar to the Little Deer project found little sediment production as a result of salvage logging activities (McIver 2006).

The PDFs that prescribe placement of waterbars on skid trails and erosion control on landings will be effective in controlling runoff and preventing off-site sedimentation. Additionally, PDFs limit the slope steepness for operating ground-based logging equipment to slopes less than 35%, which will reduce the potential for soil erosion on steeper slopes. Best Management Practice (BMP) monitoring of skid trails and landings show that water bars and erosion control measures are effective in controlling erosion and preventing sediment from reaching a stream course (USDA, 2011b). Monitoring from previous salvage projects indicates that 8% of treatment areas do not meet desired conditions for soil stability as a result of ground-based tractor logging.

There will be a loss of soil nutrients on skid trails and landings in ground based tractor units as a result of increased compaction, reduced soil cover, and soil displacement. Monitoring of previous tractor salvage units on the Klamath National Forest has found an increased amount of disturbance on secondary skid trails compared to green timber sales due to a lack of a protective duff mat on the soil surface (USDA, 2012b). PDFs including placement of waterbars, slope restrictions on ground-based equipment, and soil cover guidelines were designed to minimize the loss of soil organic matter from salvage units. Additionally, PDFs to protect CWD and retain logs and snags within salvage units will insure these features will provide soil nutrients and support soil biological functions into the future. Nutrients from logging slash, trees left on side that are too small to salvage log, trees left on site in Riparian Reserves, and trees left for wildlife habitat will all contribute to the nutrient capital from woody material in the near and long term. Monitoring from previous salvage projects indicates that 17% of treatment areas do not meet desired conditions for soil organic matter as a result of ground-based tractor logging.

Soil hydrologic function will be impacted on landings and main skid trails due to soil compaction, but with proper layout, the level of disturbance can be kept below levels that would impact stand productivity. Soil compaction leading to poor soil structure would occur on the heavily used portions of main skid trails and landings. On skid trails where machinery makes one or two passes, compaction increases only slightly; rooting environment and infiltration are not negatively affected. PDFs put limitations on the use ground based equipment during wet weather and saturated soil conditions reducing the amount of compaction on skid trails. Reusing existing skid trails will help to ensure that the area occupied by skid trails can be minimized. Additionally, sub-soiling to reduce soil compaction would occur on landings, main skid trails, and temporary roads where feasible. Monitoring from previous salvage projects indicates that 11% of treatment areas do not meet desired conditions for soil structure as a result of ground-based tractor logging.

Hazard Tree Removal

Hazard trees will be removed and harvested by ground-based tractor loggings systems. The amount of soil disturbance will be similar to the dead tree removal treatment. PDFs described above for the dead tree removal treatment will also apply to the hazard tree removal treatment.

Planting/Seeding

Planting and seeding will have a positive impact on soil cover and longer term benefit to desired conditions for organic matter. Planting and/or seeding of browse and graze species will return soil cover to the high and moderate burn areas faster than the no treatment alternative. Tree planting will benefit soil organic matter in the long term by returning the area to a conifer dominated landscape, which will provide fine and course organic inputs to rebuild organic matter lost as a result of wildfire.

Temporary Roads

Temporary roads on existing roads beds will be cleared and graded, reducing soil cover levels during project operations. Temporary roads will be hydrologically stabilized and closed after project completion, mitigating potential erosion in the project area. The upper soil layer on temporary roads can be displaced or removed when the road bed is cleared to allow log truck and equipment access. The loss of soil organic matter can impact productivity of trees growing next to temporary roads. Temporary roads will account for a minor portion of the area, so stand

productivity will not be affected. Temporary roads are not expected to meet desired conditions for soil organic matter.

Temporary roads on existing roads beds will have increased soil strength and cause reductions in infiltration and permeability. The increases in soil strength will limit the growth of trees growing next to temporary roads but because these roads occupy only a minor part of the project area, stand productivity will not be affected. While soil compaction will reduce infiltration and permeability, slash cover will reduce overland flow and prevent soil erosion. Temporary roads are not expected to meet desired conditions for soil structure, expect areas that are feasible for subsoiling.

Site Preparation

Site preparation treatments considered for this project include: felling, by low ground pressure machinery or hand piling, and pile burning. If machinery is used for site preparation, rutting and displacement will result in up to 5% of the area not meeting desired conditions for soil organic matter. PDFs that restrict equipment from traveling on steep slopes, during periods of wet weather, or during saturated soil conditions will limit the impacts of site preparation on soil desired conditions.

Firewood

Firewood cutting will have minor impacts to soil organic matter and soil structure. Minor displacement and compaction will occur along pickup truck wheel tracks. Firewood cutting will not affect desired conditions for soil organic matter or soil structure.

Cumulative Effects

Past actions including timber harvest and fire suppression are evident on the landscape in the project area and are reflected in the discussion of the affected environment. The Bray and Horsethief Grazing Allotments Project is a reasonably foreseeable future action that is being planned in the project area. Current grazing use is light in the areas proposed for treatment in the Little Deer Project. The Bray and Horsethief Grazing Allotment Project is not expected to change the level of use in the Little Deer Project Area so cumulative impacts to soil indicators are not expected to be significant.

Adding the effects of alterative 2 to the effects of past, present, and reasonably foreseeable future actions is not expected to have substantial negative effects on soil desired conditions and, therefore, no substantial negative cumulative effects will occur.

Alternative 3

Direct and Indirect Effects

The proposed activities with a potential to impact soil organic matter and soil structure are the same as Alternative 2 but the number of acres treated with ground-based tractor logging are decreased and planting/seeding is only proposed in the dead tree treatment areas. For Alternative 3, the acres that will not meet desired conditions for soil organic matter and soil structure are 315 and 207. These acres include impacts from old skid trails, landings, and roads as well as estimated additional acres from activities proposed in Alternative 3. The miles of temporary roads on existing roadbeds are slightly reduced at 9 miles. The percent of treatment acres in main skid trails and landings is expected to be slightly reduced at 7 percent.

Cumulative Effects

The cumulative effects of alternative 3 are the same as alternative 2, minus the benefit that planting/seeding would have outside of dead tree removal areas. Adding the effects of alterative 3 to the effects of past, present, and reasonably foreseeable future actions is not expected to have substantial negative effects on soil desired conditions.

Comparison of Effects

Alternative 1 has the fewest acres not meeting desired conditions for soil organic matter and soil structure at 87. These acres are found on old skid trails, landings, and roads where soil displacement and compaction are still at levels that impact soil functions. For Alternative 2, the acres that do not meet desired conditions for soil organic matter and soil structure are 367 and 232. These acres include impacts from old skid trails, landings, and roads as well as estimated additional acres from activities proposed in Alternative 2 including ground-based tractor harvest, landing construction, hazard tree removal, site preparation, and temporary road use. For Alternative 3, the number of acres treated with ground-based tractor logging is decreased, no site preparation is proposed, and there is a corresponding decrease in the acres that do not meet desired conditions for soil organic matter and soil structure at 315 and 207.

Alternative 1 will have zero miles of temporary roads on existing roadbeds. Alternative 2 will have 9.3 miles and Alternative 3 will have 9 miles of temporary roads on existing roadbeds. Reusing existing roadbeds will limit additional disturbance from project activities as these currently do not meet desired conditions for soil organic matter and soil structure. Project design features to grade, out-slope, block, and provide adequate soil cover will limit impacts to temporary roads on existing roadbeds.

Alternative 1 will have zero percent of treatment areas in main skid trails in landings as a result of project activities. Alternative 2 will have 8 percent of treatment areas in main skid trails and landings. Alternative 3 is expected to have 7 acres in main skid trails and landings, due to a reduction in acres treated with ground-based tractor logging. The majority of these will be on reused existing skid trails and landings. Implementation of project design features will reduce the potential for negative effects from these activities.

Table 4: Estimated Acres and Percent of the Treatment Area Not Meeting Desired Conditions for Soil Indicators and Activity

Activity	Alternative 1 Acres Not Meeting Desired Conditions (Estimated)	Alternative 2 Acres Not Meeting Desired Conditions (Estimated)	Alternative 3 Acres Not Meeting Desired Conditions (Estimated)
Ground Based Dead Tree Removal with Associated Landings			
Soil Stability	228	140	125
Soil Organic Matter	70	298	266
Soil Structure	70	193	172
Roadside Hazard Tree Removal			
Soil Stability	26	16	16
Soil Organic Matter	8	34	34
Soil Structure	8	22	22

Activity	Alternative 1 Acres Not Meeting Desired Conditions (Estimated)	Alternative 2 Acres Not Meeting Desired Conditions (Estimated)	Alternative 3 Acres Not Meeting Desired Conditions (Estimated)
Planting/Seeding			
Soil Stability	210	210	234
Soil Organic Matter	0	0	0
Soil Structure	0	0	0
Temporary Roads on Existing Road Beds			
Soil Stability	0	0	0
Soil Organic Matter	9	9	9
Soil Structure	9	9	9
Site Preparation			
Soil Stability	0	0	0
Soil Organic Matter	0	14	0
Soil Structure	0	0	0
Firewood			
Soil Stability	0	0	0
Soil Organic Matter	0	0	0
Soil Structure	0	0	0
Total Acres Not Meeting Desired Conditions			
Soil Stability	465	364	375
Soil Organic Matter	91	367	315
Soil Structure	91	232	207
Total % of the Treatment Area Not Meeting Desired Conditions			
Soil Stability	14%	11%	11%
Soil Organic Matter	3%	11%	9%
Soil Structure	3%	7%	6%

Compliance with law, regulation, policy, and the Forest Plan

Forest Plan Standards and Guidelines for soils will be met for all Alternatives. The number of acres that do not meet desired conditions for soil structure, soil organic matter, and soil structure is minor in relation to the project area, and is reduced to the extent possible with PDFs. Compliance with Forest-wide Standards and Guidelines for soil is shown in Table 5 below.

Table 5: Compliance with Forest-wide Standards and Guidelines for Soil

S&G No.	LRMP Direction	Project Conformance to S&G
Soils		
3-1	Plan and implement land management activities to maintain or enhance soil productivity and stability.	Complies. PDFs mitigate negative impacts of project activities on soil productivity and stability
3-2	Maintain soil cover of 70% or 80% (depending upon slope and soil type) on tractor units; maintain soil cover of 50% to 80% on prescribed burn units, depending upon slope and soil type (see LRMP, pg. 4-20). With the exception of roads, permanent facilities or other projects that will permanently occupy a site, the following levels of total soil cover should be maintained at the stand level to reduce the potential of soil erosion (see LRMP for the levels of total soils cover table):	Complies. PDFs require post treatment soil cover levels to meet this S&G. In the case where post-harvest soil cover levels are below soil cover guidelines, slash will be left on site to prevent soil erosion.
3-3	Maintain soil productivity by retaining organic material on the soil surface and by retaining organic material in the soil profile.	Complies. PDFs restrict activities that would remove surface and soil organic material to the extent where soil productivity is affected
3-4	A minimum of 50% of the soil surface should be covered by fine organic matter following project implementation, if it is available on site.	Complies. PDFs require post treatment soil cover levels to meet this S&G. In the case where post-harvest soil cover levels are below soil cover guidelines, slash will be left on site to prevent soil erosion.
3-5	Maintain a minimum of 85% of the existing soil organic matter in the top 12 inches of the soil profile to allow for nutrient cycling and maintain soil productivity.	Complies. PDFs restrict activities that would remove surface and soil organic material to the extent where soil productivity is affected
3-6	Refer to the Coarse Woody Debris (CWD) section of Biological Diversity under Biological Environment for coarse woody debris standards and guidelines designed to maintain soil fertility and provide for species needs.	Complies. PDFs require protecting pieces of CWD during project activities
3-7	Complete a Soils Resource Inventory Order 2 inventory when necessary, or field verify the Soils Resource Inventory Order 3 survey, during the planning and implementation phase of each site-disturbing or vegetative manipulation project. Develop soil conservation management practices for each project as needed.	Complies. The Order 3 soil survey was field verified during the planning of this project

Summary of effects and their relationship to significance factors

Below is a summary of effects and their relationship to significance factors (context and intensity) to support a finding of no significant impact, as it relates to the soil resource (40 CFR 1508.27). Intensity factors for soils are shown in Table 6 below.

Table 6: Soil Analysis Intensity Factors for an EA

INTENSITY FACTORS	HOW APPLICABLE TO THE SOIL RESOURCE
Beneficial and adverse impacts	Provides long-term protection for soil productivity for the project area. No significant impacts.
The degree to which the proposed action affects public health	None
Unique characteristics of the geographic area	None. Soil in the Project area does not have unique characteristics such as prime farmland.
The degree to which the effects on the human environment are likely to be highly controversial	None
The degree to which the possible effects on the human environment are highly uncertain or involve unique or unknown risks	None. Monitoring data of similar activities from previous projects on the Klamath National Forest provide a reasonable degree of certainty of possible effects.
The degree to which the action may establish a precedent for future actions with significant effects or represents a decision in principle about a future consideration	None
Whether the action is related to other actions with individually insignificant but cumulatively significant impacts	None. No significant cumulative effects to the soil resource are expected.
The degree to which the action may adversely affect districts, sites, highways, structures, or objects listed in or eligible for listing in the National Register of Historic Places, or may cause loss or destruction of significant scientific, cultural, or historical resources	None
The degree to which the action may adversely affect an endangered or threatened species or its habitat that has been determined to be critical under the Endangered Species Act of 1973	None
Whether the action threatens a violation of Federal, State, or local law or other requirements imposed for the protection of the environment	No

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Appendix A – Soil Map of the Project Area

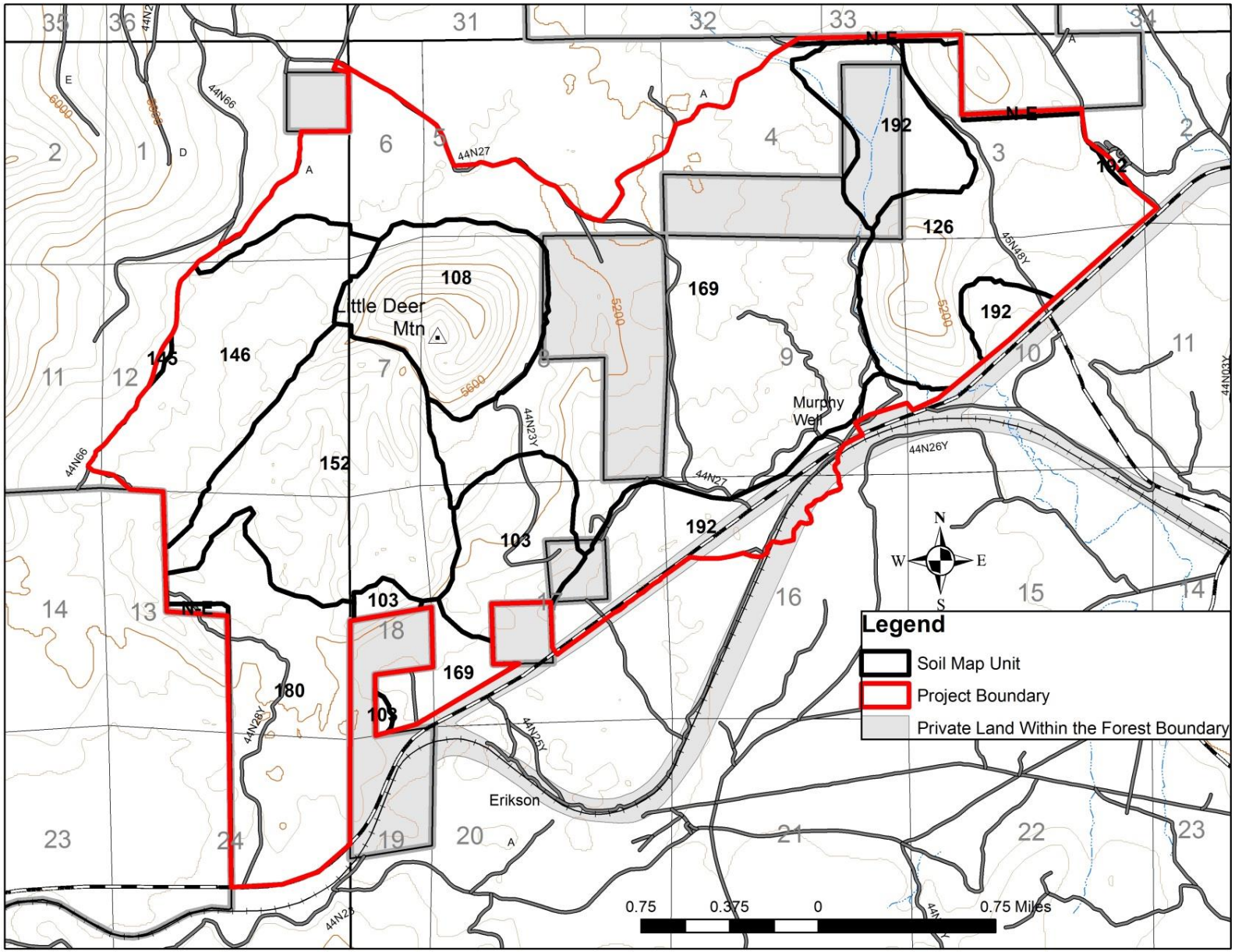

Figure A- 1: Soil map of the project area

Appendix B – Soil Map Unit Characteristics

Soil Map Unit Number	Map Unit Name	Parent Material	Surface Texture	Soil Depth (in)	Soil Productivity	Maximum EHR	Acres in Project Area
103	Avis-Oosen families complex, 15 to 50 % slopes	volcanic ash	sand	201	M	M	227
108	Cinder lands.	cinders	cinders	201	Un-productive	L	330
126	Etchen-Neuske families complex, 9 to 30 % slopes	residuum weathered from andesite	loam	102	L	M	537
145	Inville family, 15 to 50 % slopes	residuum weathered from igneous rock	gravelly loam	76	M	M	4
146	Inville-Wintoner families complex, 2 to 15 % slopes	residuum weathered from igneous rock	gravelly loam	76	M	M	438
152	Lava flows	residuum weathered from volcanic rock	unweathered bedrock	0	Un-productive	L	558
169	Oosen-Avis families comlpex, 2 to 15 % slopes	volcanic ash	sandy loam	201	L	M	1747
180	Sheld-Iller families complex, 5 to 50 % slopes	volcanic ash	sandy loam	86	M	M	449
192	Trojan-Kilmerque families assn., 2 to 9 % slopes	residuum weathered from basalt	loam	147	M	M	526

Appendix C – Soil Interpretations- Alternative 2

Unit #	Acres	Treatment	Dominant Soil Map Unit	Field data collected	Compaction Hazard Rating	Current soil cover %	Soil Burn Severity	Erosion Hazard Rating			Post-Project Soil Cover (%)
								Current	Maximum	Post-Project	
718-101	7	DTR	146		M	61	M	L	M	L	70
718-102	109	DTR	180		L	61	M	L	M	L	70
718-105	9	DTR	180		L	61	M	L	M	L	70
718-106	176	DTR	180		L	61	M	L	M	L	70
718-107	1	DTR	180		L	61	M	L	M	L	70
718-108	12	DTR	180		L	61	M	L	M	L	70
718-109	6	DTR	169		L	61	M	L	M	L	70
718-110	15	DTR	192		M	61	M	L	M	L	70
718-112	15	DTR	192		M	61	M	L	M	L	70
718-113	20	DTR	146		M	61	M	L	M	L	70
718-122	2	DTR	180		L	61	M	L	M	L	70
718-124	2	DTR	180		L	61	M	L	M	L	70
718-34-3	16	DTR	169		L	61	M	L	M	L	70
718-34-4	27	DTR	169		L	61	M	L	M	L	70
718-35-2	135	DTR	146	X	M	32	H	M	M	L	70
718-35-4	17	DTR	146		M	61	M	L	M	L	70
718-35-5	11	DTR	146		M	61	M	L	M	L	70
718-8-2	6	DTR	103	X	L	32	H	M	M	L	70
718-8-3	108	DTR	169	X	L	32	H	M	M	L	70
718-8-4	6	DTR	103		L	61	M	L	M	L	70
718-86	41	DTR	169	X	L	32	H	M	M	L	70
718-89	1	DTR	180		L	61	M	L	M	L	70
718-90	37	DTR	108		L	32	H	M	L	L	70
718-92	9	DTR	169	X	L	32	H	M	M	L	70
718-93	74	DTR	192		M	61	M	L	M	L	70
718-98	66	DTR	169	X	L	61	M	L	M	L	70
718-99	36	DTR	169	X	L	61	M	L	M	L	70
719-18-1	31	DTR	126	X	M	61	M	L	M	L	70
719-18-2	11	DTR	126	X	M	61	M	L	M	L	70
719-19-1	34	DTR	192		M	61	M	L	M	L	70
719-19-2	2	DTR	192		M	61	M	L	M	L	70
719-19-4	3	DTR	192		M	61	M	L	M	L	70
719-24-2	3	DTR	169		L	61	M	L	M	L	70
719-24-3	2	DTR	169		L	61	M	L	M	L	70
719-4-2	1	DTR	126		M	61	M	L	M	L	70

Unit #	Acres	Treatment	Dominant Soil Map Unit	Field data collected	Compaction Hazard Rating	Current soil cover %	Soil Burn Severity	Erosion Hazard Rating			Post-Project Soil Cover (%)
								Current	Maximum	Post-Project	
719-4-3	1	DTR	126		M	61	M	L	M	L	70
719-4-5	107	DTR	192	X	M	61	M	L	M	L	70
719-4-6	11	DTR	192	X	M	61	M	L	M	L	70
719-5-2	33	DTR	126	X	M	61	M	L	M	L	70
719-6-1	44	DTR	192		M	61	M	L	M	L	70
719-62	29	DTR	126		M	61	M	L	M	L	70
719-63	13	DTR	126		M	61	M	L	M	L	70
719-64	64	DTR	169		L	61	M	L	M	L	70
719-6-4	5	DTR	126		M	61	M	L	M	L	70
719-67	29	DTR	169		L	61	M	L	M	L	70
719-69	11	DTR	169		L	61	M	L	M	L	70
719-7-2	1	DTR	169		L	61	M	L	M	L	70
719-7-3	18	DTR	169		L	32	H	M	M	L	70
719-74	34	DTR	126		M	61	M	L	M	L	70
719-75	4	DTR	126		M	61	M	L	M	L	70
719-80	71	DTR	169		L	61	M	L	M	L	70
719-8-10	2	DTR	169		L	61	M	L	M	L	70
719-8-11	3	DTR	169		L	61	M	L	M	L	70
719-83	12	DTR	169		L	61	M	L	M	L	70
719-8-3	51	DTR	169		L	61	M	L	M	L	70
719-84	56	DTR	126	X	M	61	M	L	M	L	70
719-8-4	13	DTR	169		L	61	M	L	M	L	70
719-85	17	DTR	169		L	32	H	M	M	L	70
719-86	6	DTR	169		L	61	M	L	M	L	70
719-8-6	68	DTR	169		L	61	M	L	M	L	70
719-87	8	DTR	169		L	32	H	M	M	L	70
719-8-7	2	DTR	169		L	61	M	L	M	L	70
719-88	1	DTR	169		L	61	M	L	M	L	70
719-8-8	1	DTR	169		L	61	M	L	M	L	70
719-89	5	DTR	126		M	61	M	L	M	L	70
719-95	4	DTR	169		L	61	M	L	M	L	70
719-96	19	DTR	169		L	61	M	L	M	L	70
732-27-1	28	DTR	192		M	61	M	L	M	L	70

DTR= Dead Tree Removal

* In the case where post-harvest soil cover levels are below soil cover guidelines, slash will be left on site to prevent soil erosion.